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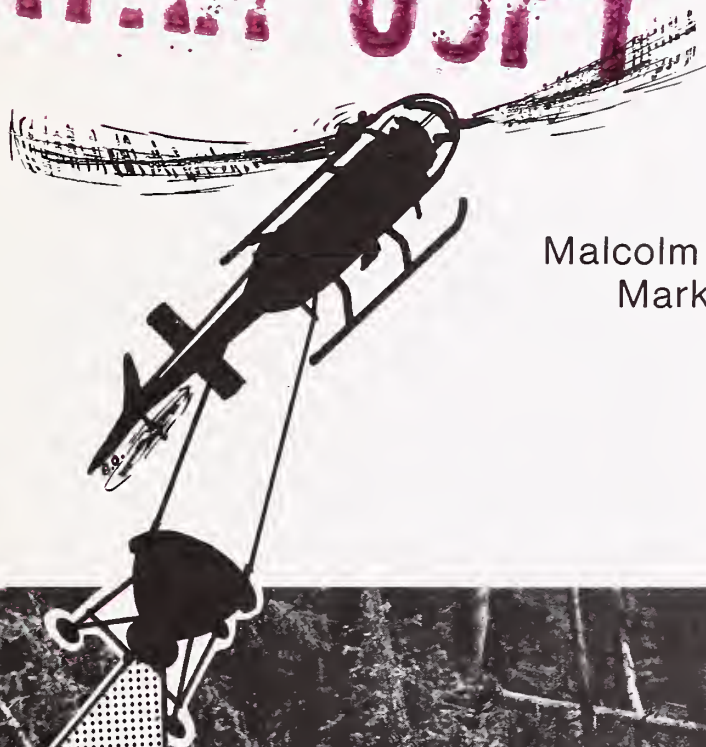
Intermountain  
Forest and Range  
Experiment Station

General Technical  
Report INT-101

April 1981

# Effectiveness of Douglas-Fir Beetle Antiaggregative Pheromone Applied by Helicopter

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## ACKNOWLEDGMENTS

Many persons contributed to the earlier developmental work that led to this test as noted in the cited publications. The antiaggregative pheromone, 3-methyl-2-cyclohexen-1-one (MCH), was formulated for the test by Zoecon Corporation through arrangement with Dr. J. W. Young of that company. F. W. Honing, USDA Forest Service, Washington, D.C., assisted in obtaining an experimental use permit for the test. MCH content of the formulation was checked independently by Dr. M. Look, USDA Forest Service, Berkeley, Calif. Application technology was developed with the aid of R. Mosmeir, Simplex Corporation, Portland, Oreg.; A. E. Jasumbach, D. R. Hamel, D. R. Bridgewater, USDA Forest Service; and P. E. Joseph, Oregon Department of Forestry. V. J. Hager, USDA Forest Service, corrected mechanical difficulties with the applicator and designed improvements. C. R. Hepner, USDA Forest Service, and N. S. Mehaffie, University of Idaho, supervised the field work and assisted with analyses. Others assisting with fieldwork were K. Gibson, USDA Forest Service, and D. E. Beckman, Idaho Department of Lands. J. Kover, Burlington Northern, Inc., obtained permission for us to locate plots on that company's land. The manuscript was reviewed by Dr. R. A. Werner, Fairbanks, Alaska, Drs. R. D. Averill and E. Holsten, Anchorage, Alaska, M. M. Ollieu, Ogden, Utah, all USDA Forest Service; Dr. W. F. Barr, University of Idaho, Moscow, Idaho; and L. N. Kline, Oregon Department of Forestry, Salem, Oreg.

## RESEARCH SUMMARY

A granular controlled release formulation containing approximately 1.7 percent Douglas-fir beetle anti-aggregative pheromone, 3-methyl-2-cyclohexen-1-one, was applied prior to beetle flight by helicopter to replicated 2 hectare plots each containing 10 felled Douglas-firs. Rates of application ranged from 1.41 to 9.80 kg/ha as measured on plots by 0.28 square meter conical traps. Bark samples taken in August disclosed that the pheromone treatments had reduced Douglas-fir beetle attacks by 92 to 97 percent and progeny by 93 to 99 percent. Results were consistent with earlier tests involving hand broadcasting the controlled-release formulation on smaller plots. Information is also presented concerning relationship of Douglas-fir beetle infestation to tree and site variables and densities of other insects on bark samples including entomophagous species. The controlled-release formulation is now ready for pilot testing to prevent expansion of Douglas-fir beetle populations in Douglas-fir windthrow and subsequent killing of susceptible trees in surrounding stands.

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# Effectiveness of Douglas-Fir Beetle Antiaggregative Pheromone Applied by Helicopter

## INTRODUCTION

The Douglas-fir beetle (DFB) (*Dendroctonus pseudotsugae* Hopkins) ranks among the most economically important bark beetles. Like other bark beetles, its level of abundance and destructiveness is mainly an expression of the prevailing condition of its host trees and stand environment (Furniss, McGregor, and others 1979; Furniss and others, 1981). Beetle populations increase when damaged trees (for example, wind-thrown trees) are available. Because they lack resistance, windthrown trees produce many more beetle progeny than there are attacking beetles. The number of standing trees killed by those progeny after emergence is a function of abundance of beetles and availability of dense, mature Douglas-fir stands. Such stands are made more susceptible by drought, and possibly by infection with root rots or defoliation by Douglas-fir tussock moths (Berryman and Wright 1978).

Removal of damaged trees and regulation of stand density are powerful points of leverage for interrupting the genesis of Douglas-fir beetle outbreaks. Where possible, windthrown trees should be logged and stand basal area kept below 80 percent of normal stocking. In inaccessible stands, however, an alternative means of relieving the potential for increase of the beetle population is needed. To meet this need, the beetles' anti-aggregative pheromone, 3-methyl-2-cyclohexen-1-one (MCH), is being developed for application to prevent infestation of susceptible felled trees.

MCH was chosen for development in preference to trapping out DFB with an aggregative pheromone such as frontalin because of serious disadvantages of the latter (Furniss 1972): a predacious clerid beetle, *Thanasimus undatulus* Say, is attracted and destroyed in disproportionate numbers to its prey; attracted DFB's

"spill over" into trees surrounding the pheromone source causing additional mortality, and if attractant pheromones are used in a "confusion" strategy, vast numbers of trees might be sublethally attacked by DFB, but fatally inoculated with fungi carried by the beetles (Harrington and others 1981).

MCH represses the attraction created when female beetles invade their host tree (Furniss and others 1972; Rudinsky and others 1972). The natural function of MCH is to terminate attack in trees that have been colonized by a sufficient number of female beetles and their mates (Rudinsky and Ryker 1976). MCH has the same effect on the spruce beetle, *Dendroctonus rufipennis* [Kirby] (Kline and others 1974; Furniss and others 1976). MCH treatment may be ineffective, however, unless applied in the spring prior to initiation of beetle flight and where beetles are below outbreak population density (Furniss, Baker, and others 1979).

The optimum treatment for preventing DFB infestation in susceptible felled trees is approximately 0.25-2.5 g of MCH evaporated per hectare per day (Furniss and others 1974). A granular controlled-release formulation (CRF) containing 2 percent MCH has been developed (U.S. Patent No. 4,170,631) that significantly reduced Douglas-fir beetle attacks in susceptible felled trees when broadcast at 4.6 kg/ha by hand (Furniss and others 1977). We now report the effectiveness of the CRF applied by helicopter to larger plots containing felled Douglas-fir to simulate windthrow.

The DFB population was at a low level during the test. Prevention of "epidemics" by holding the status quo of such low populations in the presence of windstorm damage is the primary objective in using MCH.

## METHODS

The study was located between 1 018 and 1 323 m elevation in the upper Palouse River drainage, Latah County, Idaho, in a mixed conifer forest typical of large, productive areas of northern Idaho in which Douglas-fir occurs abundantly as a seral species. Thirty 2-ha plots (122 m x 168 m) were located at 0.4 km or greater intervals along logging roads. The plots were divided into clusters of three, within which each plot was assigned a treatment in the following order: 17.93 kg CRF/ha, control, and 4.48 kg CRF/ha.

During March 13 to 21, 1979, 10 live Douglas-firs were felled on each plot. They averaged 46 cm d.b.h. ( $R = 33$  to 110.5 cm) and 94 years old ( $R = 70$  to 200+). The CRF was applied to plots on April 23 and 24 with a Simplex model 3700 (1.13 m<sup>3</sup>) aerial spreader suspended 15 m above the forest canopy from a Bell Jet helicopter (fig. 1 A,B) flying about 72 km/hr. The spreader was modified to restrict output to that required for the test, and the swath width had been determined by airport tests as will be discussed. Application rate was checked with fifteen 0.28 m<sup>2</sup> conical traps per plot (fig. 2 A,B) spaced 24 m apart on three lines 61 m apart and right angle to the direction of flight.

Effectiveness of treatments was checked initially by counting frass piles on May 30 and 31 when most DFB

attacks had occurred. All visible frass piles were counted on the stems of each felled tree. Bark samples were removed in August to determine final densities of attacks and progeny. Attacks were counted and galleries were measured on one-half x 2 m samples at 6 m height on the stem and on 30 X 30 cm samples at one-fourth intervals between stump and a 20.3 cm top diameter. Progeny were counted on 15 X 15 cm sub-samples.



Figure 2.—(A) Conical trap used to determine rate of application of controlled-release granules on plots; (B) Detail of receptacle and wire support attached to bottom of trap to catch granules.

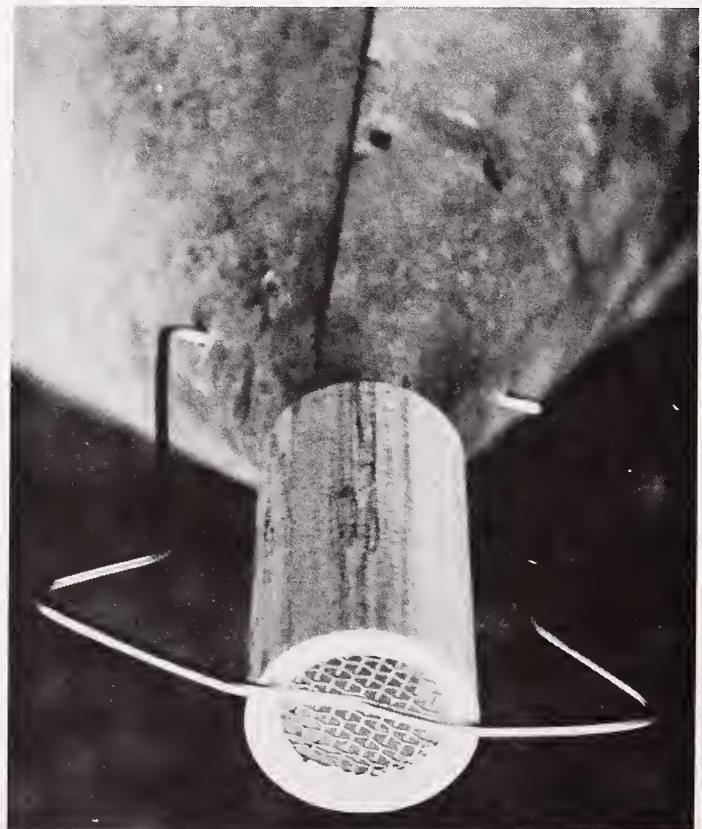


Figure 1.—(A) Aerial spreader and helicopter used to apply controlled-release formulation of MCH; (B) MCH granules.

## Analyses

Treatment effect was tested for each set of DFB population samples and infestation indices by analysis of variance. Relationship between weight of CRF granules caught on plots and density of DFB infestation was examined by plotting each observation with a Zeta increment pen plotter. Weights of granules were also plotted against density of stands surrounding cone traps in terms of basal area and an ocular estimate of overhead crown density.

Variables, other than treatment, significantly correlated with low and high DFB infestation intensity were sought by applying the SCREEN computer program (Hamilton and Wendt 1975). Variables analyzed were: light intensity in foot candles at the sample location expressed as a percent of full sunlight at that hour of day, d.b.h., age, last 10-year growth, and phloem thickness. DFB infestation intensity per plot was tested by stepwise regression analysis against elevation, aspect, topographic position, and average basal area.

The newly formulated CRF was analyzed and found to contain 1.7 percent MCH, slightly less than the desired 2 percent. At the time of application a second sample of CRF was extracted and checked for MCH content by the formulator and an independent laboratory. The MCH content was in the range of  $1.2 \pm 0.2$  percent, substantially less than the freshly formulated material a month earlier.

## RESULTS AND DISCUSSION

### Application of CRF

Airport tests determined that the overall swath width was about 37 m. A 15-m working swath width was chosen after examination of the horizontal distribution of granules in order to provide overlap sufficient to achieve an even distribution of the desired rate.

During application of granules, difficulties were encountered with the aerial applicator that resulted in a range of output of granules rather than replications of the two programmed rates. Since then, these difficulties have been resolved by changes in design, information about which will be published separately.

The average density of granules caught by traps on plots was 1.96 kg/ha,  $R = 1.41$  to  $2.61$  for the low rate and 6.80 kg/ha,  $R = 4.19$  to  $9.80$  for the high rate. Rates lower than intended were due mainly to the mechanical problems mentioned but interception of granules by trees may have been involved even though collection of granules was delayed one day to provide time for them to become dislodged.

Weight of granules caught per cone was not strongly related to stand density in terms of basal area or crown density at the cone. Diminished catch of granules was

evident, however, at basal areas greater than 51.65 m<sup>2</sup>/ha and the highest crown density class.

## Reduction of DFB Infestation

Trees were examined May 10 but no DFB attack was found. A second examination on May 22 disclosed that attacks had begun during the interim. On May 30 and 31, frass piles on the upper 60 percent of circumference of all trees were counted to compare relative rates of attack:

Treatment	Number of attacks	trees infested
Control	2,453	92
MCH, lower rate	110	41
MCH, higher rate	64	29

The two MCH treatments reduced attacks by 95 and 97 percent compared to the controls. Plots treated at higher rate of application had 42 percent fewer attacks and 29 percent fewer infested trees compared to the lower rate.

Some attacks were yet to occur, however, so we postponed final evaluation until August 1 through 20 when all eggs would have hatched and progeny could be counted. The proportions of life stages on August samples were 74 percent larvae, 18 percent pupae, and 8 percent new adults.

Results of the August sampling are contained in table 1. MCH treatment reduced attack density between 93 and 99 percent and progeny by a similar amount (92 to 99 percent). Both MCH treatments differed significantly ( $p > 0.01$ ) from controls. The higher rate of treatment reduced infestation more than the lower rate, except for numbers of progeny, but the differences were not significant.

DFB attacks were approximately twice as dense on the skyward side than on the underside of tree stems. Probably, temperature on the skyward side of stems was favorable for beetles to bore during initial attack; later, when that side became heated, too few beetles remained in flight to exploit the underside as they normally do (Furniss 1962). In support of this possibility, we found that light intensity of sample locations was positively correlated with attack density. This is not the normal relationship as can be inferred from the work of Rudinsky and Vitè (1956). In most years, samples would include more DFB attacks and progeny on the underside and should be taken there unless examination discloses otherwise.

Attack density varied considerably between the four sampling positions on the stems of plot trees (fig. 3). The highest sampling position (20.3 cm diameter) was least productive of DFB attacks and the test could have been evaluated more efficiently without it.

Table 1.—Densities of Douglas-fir beetle infestation on samples from upper and lower sides of plot trees<sup>1</sup>

Treatment	Upper side		Lower side	
	Attacks	Gallery length	Attacks	Progeny
	Number/m <sup>2</sup>	cm/m <sup>2</sup>	Number/m <sup>2</sup>	
Control	6.9	170.2	<sup>2</sup> 2.7	68.9
MCH, lower	0.5	7.6	0.1	2.1
MCH, higher	0.06	1.0	0.05	5.4

<sup>1</sup>Upper side samples were 0.5 x 2.0 m on which attacks and gallery length were determined; lower side samples were 30 x 30 cm for attacks and 15 x 15 cm for progeny.

<sup>2</sup>Average = 3.5 if the unproductive top (20 cm diameter) sample position is omitted; meanwhile, average for MCH not affected.

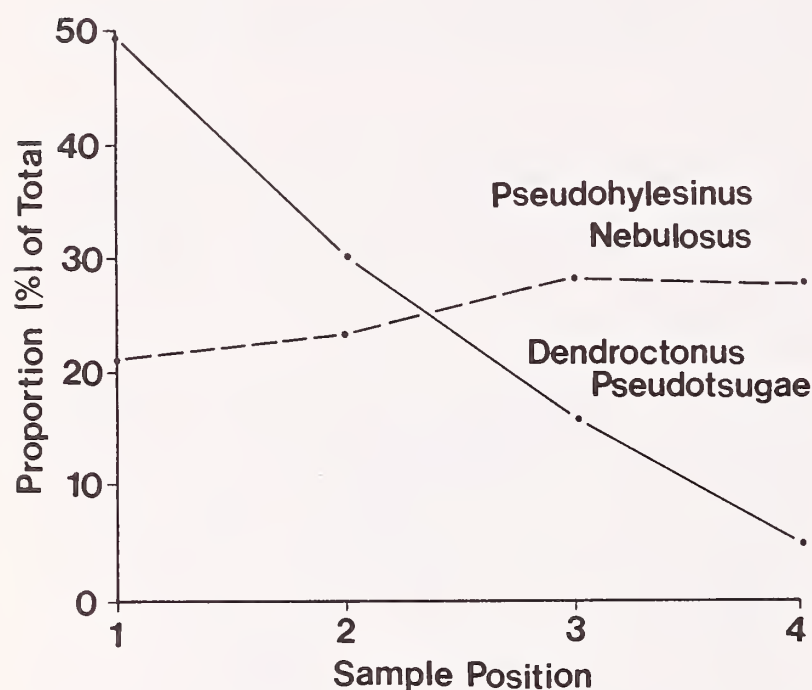


Figure 3.—Distributions of Douglas-fir beetle and *Pseudohylesinus nebulosus* by location of sample.

## Relationships of Nontreatment Variables with DFB Infestation

We noted a wide range of DFB attack density within and between plots of the same treatment category (especially controls). Because treatment could not explain those differences, we sought to correlate other variables with density of infestation.

Thirty pairs of trees having lowest (mostly zero) and highest DFB attack density were tested by the SCREEN program to determine if the following variables were correlated significantly ( $p = 0.05$ ) with presence or

absence of DFB: relative light intensity at the sample, age, d.b.h., last 10 years' growth, and phloem thickness. None was significantly correlated in this particular instance. We know from personal observation, however, that those variables are normally positively correlated with successful DFB attacks.

We also looked for possible relationships between plot characteristics and DFB attack density, by applying stepwise multiple regression analysis. Factors regressed on DFB attack density were: elevation, aspect, basal area, topographic position, and slope. None of those factors was related significantly to intensity of DFB infestation.

We conclude that the extremely low DFB population resulted in the wide range of attack density. We think that beetles tended to aggregate on the first attacked trees and that other plot trees were not attacked subsequently because there were virtually no more beetles available. The objective of the test was attained, however, because we determined that MCH effect on this endemic population was proportional to that on a many times greater population in previous years (Furniss and others 1974, 1977).

## Other Insects

The scolytid, *Pseudohylesinus nebulosus* (Lec.), was the most abundant insect in plot trees. Its attacks preceded those of the DFB. Rate of occurrence of *P. nebulosus* on samples increased with sampling height (fig. 3). MCH had no effect on frequency of occurrence of *P. nebulosus* in plot trees.

Larvae of the weevil, *Pissodes fasciatus* Lec, were present more often ( $p = 0.01$ ) on MCH plot trees. Frequencies of infested samples by treatment were: MCH, higher rate (131), MCH, lower rate (108), and control (61).

Table 2.—Average densities per square meter of insect predators and a parasite by treatment

Treatment	<i>Coeloides vancouverensis</i>	<i>Medetera sp.</i>	Cleridae	<i>Temnochila chlorodia</i>
Control	27.8	2.9	2.0	0.1
MCH, lower	7.4	0	.1	0
MCH, higher	.1	0	.1	0

Another scolytid, *Scolytus monticolae* Sw., began infesting trees in early July, but was relatively rare, being present on only 16 of 1,200 bark samples (1.3 percent). It was twice as frequent in the upper one-half of the trunk as in the basal one-half, but was unaffected by MCH treatment.

Five species of entomophagous insects were tallied on samples (table 2). MCH has no known effect on them. Their order of abundance was the same as observed in previous years (Furniss and others 1979). The braconid wasp, *Coeloides vancouverensis* (Dalla Torre) (= *brunneri* Vier.), was most abundant, followed by a dolichopodid fly, *Medetera* sp., clerid beetles, including *Thanasimus undatulus* Say and *Enoclerus sphegeus* Fab., and the ostomid, *Temnochila chlorodia* Mann. These species appear to be more important controlling factors at low DFB population densities inasmuch as their densities in trees did not change markedly during the course of an outbreak not far from this test area (Furniss and others 1979). Thus, working in concert with MCH treatment, entomophagous insects might exert additional controlling influence.

## CONCLUSIONS AND RECOMMENDATIONS

Results of the test confirm earlier findings and indicate that aerial application of 4.48 kg CRF/ha will reduce by over 90 percent infestation of windthrown Douglas-fir by Douglas-fir beetles. Effectiveness of MCH treatment was evaluated with similar accuracy using any of the three sets of sample data described earlier. Attack density, however, was more easily determined by counting frass piles than by removing bark samples, and the data were available sooner. Frass must be counted when attacks are nearly complete, but before frass is blown or washed away. Approximately June 1 is a suitable time in areas represented by this study.

Because MCH has no demonstrable direct effect on entomophagous insects that help to maintain low DFB population densities (Furniss and others 1979), it is preferable to aggregative pheromones (frontalin or seudenol). Frontalin and seudenol attract the predator, *Thanasimus undatulus* in disproportionate numbers and would result in its destruction in a trap-out effort. An even more worrisome aspect of the use of aggregative pheromones—especially in a “confusion” strategy—where those pheromones would be applied areawide to the forest, is the possibility of trees being attacked at a sublethal density that would result in inoculating vast numbers of trees with fungi. *Fomitopsis pinicola* (Sw. ex Fr.), *Cryptoporus volvatus* (P.), and other fungi are known to be carried by the beetles (Harrington and others 1981).

Application of the CRF to emit MCH throughout the spring beetle flight would provide an alternative to leaving inaccessible windthrow untreated. When sufficient merchantable size Douglas-firs are felled by windstorms, the CRF will be pilot tested on large (40 to 120 ha) replicated plots at a rate of 4.48 kg/ha for comparison with similar but untreated areas. Registration requirements are being determined in consultation with the Environmental Protection Agency.

Other recommended future research includes testing the CRF against spruce beetle, which breeds to epidemic numbers in felled spruces in many areas of western North America, and applying the controlled-release technology to develop pine engraver inhibitory pheromone (Birch and others 1977; Furniss and Livingston 1979) for prevention of outbreaks in pine slash.

## PUBLICATIONS CITED

- Berryman, A. A., and L. C. Wright.  
1978. Defoliation, tree condition, and bark beetles. Part 1, Chapter 4.5 *In* The Douglas-fir tussock moth: a synthesis. M. H. Brookes, R. W. Stark, and R. W. Campbell, eds. USDA Tech. Bull. 1585, p. 81-87.
- Birch, M. C., D. M. Light, and K. Mori.  
1977. Selective inhibition of response of *Ips pini* to its pheromone by the (S)-(-) enantiomer of ipsenol. *Nature* 270:738-9.
- Furniss, M. M.  
1962. Infestation patterns of Douglas-fir beetle in standing and windthrown trees in southern Idaho. *J. Econ. Entomol.* 55:486-491.
- Furniss, M. M.  
1972. Bark beetle attractants and repellants. *Western For. and Conserv., Western For. Pest Comm. Proc.*, Seattle, Wash. p. 44-48.
- Furniss, M. M., B. H. Baker, and B. B. Hostetler.  
1976. Aggregation of spruce beetles (Coleoptera) to seudenol and repression of attraction by methylcyclohexenone in Alaska. *Can. Entomol.* 8:1297-1302.
- Furniss, M. M., B. H. Baker, R. A. Werner, and L. C. Yarger.  
1979. Characteristics of spruce beetle (Coleoptera: Scolytidae) infestation in felled white spruce in Alaska. *Can. Entomol.* 111:1355-1360.
- Furniss, M. M., G. E. Daterman, L. N. Kline, M. D. McGregor, G. C. Trostle, L. F. Pettinger, and J. A. Rudinsky.  
1974. Effectiveness of the Douglas-fir beetle anti-aggregative pheromone methylcyclohexenone at three concentrations and spacings around felled host trees. *Can. Entomol.* 106:381-392.
- Furniss, M. M., L. N. Kline, R. F. Schmitz, and J. A. Rudinsky.  
1972. Tests of three pheromones to induce or disrupt aggregation of Douglas-fir beetles in live trees. *Ann. Entomol. Soc. Am.* 65:1227-1232.
- Furniss, M. M., and R. L. Livingston.  
1979. Inhibition by ipsenol of pine engraver attraction in northern Idaho. *Environ. Entomol.* 8(2):369-372.
- Furniss, M. M., R. L. Livingston, and M. D. McGregor.  
1981. Development of a stand susceptibility classification for Douglas-fir beetle. *Proc. symp., hazard rating systems in forest pest management* [Univ. Georgia, Athens, Ga., July 31-Aug 1, 1980]. (In press.)
- Furniss, M. M., M. D. McGregor, M. F. Foiles, and A. D. Partridge.  
1979. Chronology and characteristics of a Douglas-fir beetle outbreak in Northern Idaho. *USDA For. Serv. Gen. Tech. Rep. INT-59*, 19 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.
- Furniss, M. M., J. W. Young, M. D. McGregor, R. L. Livingston, and D. R. Hamel.  
1977. Effectiveness of controlled-release formulations of MCH for preventing Douglas-fir beetle (Coleoptera:Scolytidae) infestation in felled trees. *Can. Entomol.* 109:1063-1069.
- Hamilton, D. A., Jr., and D. L. R. Wendt.  
1975. SCREEN: a computer program to identify predictors of dichotomous dependent variables. *USDA For. Serv. Gen. Tech. Rep. INT-22*, 20 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.
- Harrington, T. C., M. M. Furniss, and C. G. Shaw.  
1981. Dissemination of Hymenomyces by *Dendroctonus pseudotsugae* (Coleoptera:Scolytidae). *Phytopathology* (In press).
- Kline, L. N., R. F. Schmitz, J. A. Rudinsky, and M. M. Furniss.  
1974. Repression of spruce beetle (Coleoptera) attraction by methylcyclohexenone in Idaho. *Can. Entomol.* 106:485-491.
- Rudinsky, J. A., M. M. Furniss, L. N. Kline, and R. F. Schmitz.  
1972. Attraction and repression of *Dendroctonus pseudotsugae* (Coleoptera:Scolytidae) by three synthetic pheromones in sticky traps in Oregon and Idaho. *Can. Entomol.* 104:815-822.
- Rudinsky, J. A., and L. C. Ryker.  
1976. Olfactory and auditory signals mediating behavioral patterns of bark beetles. *Coll. Int. CNRS 265 - Comportement des Insectes et Milieu Trophique* (Tours, France), (Sept. 13-17, 1976), p. 195-209.
- Rudinsky, J. A., and J. P. Vité.  
1956. Effects of temperature upon the activity and the behavior of the Douglas-fir beetle. *For. Sci.* 2:258-267.

Furniss, Malcolm M., Russell W. Clausen, George P. Markin, Mark D. McGregor, and R. Ladd Livingston.

1981. Effectiveness of Douglas-fir beetle antiaggregative pheromone applied by helicopter. USDA For. Serv. Gen. Tech. Rep. INT-101, 6 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

A controlled-release formulation containing 1.7 percent antiaggregative pheromone, 3-methyl-2-cyclohexen-1-one, was applied by helicopter at rates between 1.41 and 9.80 kilograms of controlled-release formulation per hectare to 2-hectare plots each containing 10 simulated windthrown Douglas-fir. Treatment reduced Douglas-fir beetle infestation in felled trees by 92 to 99 percent compared to untreated plots.

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KEYWORDS: Douglas-fir beetle, 3-methyl-2-cyclohexen-1-one, MCH, pheromone, controlled-release formulation, preventive control

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